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Characteristics of Effluent from Medical Wastewater Treatment: A Case Study in Vietnamese Mekong Delta

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Abstract

The study evaluates the current status of wastewater quality after treatment at major medical facilities in Vietnamese Mekong Delta province. Medical wastewater samples were collected at eight locations (designated from YT1 to YT8) including two general hospitals and six district health centers during the period from March to May 2020. The quality of effluents is evaluated based on the National Technical Regulations on quality of medical wastewater into water used for domestic purposes (QCVN 28:2010/BTMNT, Column A). The effluent parameters including pH, total suspended solids (TSS), biochemical oxygen demand (BOD) and chemical oxygen demand (COD), phosphate (PO_4^{3-}), nitrate (NO_3^-), ammonium (NH_4^+), sulfide (S^{2-}) and coliform were used for the assessment. The results showed pH, TSS, BOD, COD, NO_3^- and coliform did not pass the standard limits. pH was high at YT8, TSS was high at YT1. BOD and COD were high at YT4 while NO_3^- was high at YT1, YT2, YT3 and YT5. Density of coliform was always high in the effluents. The effluent at YT1 was at the highest pollution level while that of YT8 met most of the discharge requirements, except for pH. The study found that effluents from medical wastewater treatments are one of the key sources of surface water pollution. Appropriate actions are urgently needed to improve efficiency of the medical wastewater treatment systems since it currently works inefficiently.

1. Introduction

In the context of increasingly developing science and technology, human health is also of much concern and focus. The medical field is invested in development and continuous innovation so as to create improved achievements and useful research works for the cause of care and protection of human health. Since then, the demand for health care services is gradually increasing. Health care services require the use of chemicals to ensure the process of diagnosis, treatment, surgery, sterilization, etc., leading to waste, medical wastewater containing large concentrations of antibiotics, anti-inflammatory drugs, disinfectants are released into the environment [1].

Along with the patient's excretory process and common and specific pollutants such as organic matter, minerals, radioactive isotopes, microorganisms, etc., medical wastewater becomes difficult

to treat because it contains many complex pollutants [2-4]. Therefore, it is very important to study and evaluate the quality of medical wastewater after treatment. Bac Lieu is a coastal province in the Mekong Delta that is in the process of building and developing the province's socio-economic situation in the 2016-2020 period. In which, the health sector also receives a lot of attention and being called for investment and development [4].

The demand for medical examination and treatment of patients in the area has also increased, leading to more wastewater generated and this may cause pressure on wastewater treatment at medical facilities. Currently, there are not many studies on the characteristics of the output of water quality from medical wastewater treatment systems. Therefore, research on the quality of medical wastewater after treatment is very necessary. The current findings could provide scientific information of medical wastewater treatment status and surface water polluting source in the study area.

2. Materials & Methods

2.1. Data collection

The medical effluent water monitoring data was collected from the Department of Natural Resources and Environment of Bac Lieu province in 2020 for the period from March to May in 2020 at eight hospitals and medical centers. The monitoring locations are described, denoted and presented in **Table 1**. The quality of treated medical wastewater is evaluated using nine parameters including pH, chemical oxygen demand (COD), demand biological oxygen demand (BOD), suspended solids (TSS), phosphate (PO_4^{3-}), nitrate (NO_3^-), ammonium (NH_4^+), sulfide (S^{2-}) and coliform.

The pH was measured in the field while the remaining parameters were collected, transported and analyzed in the laboratory according to the standard method [5]. The methods of measurement and analysis of water effluent samples is presented in **Table 2**.

Table 1: Summary of medical wastewater effluent sampling location

No.	Code	Sites	Coordinates	
			X	Y
1	YT1	Hospital 1	579077	1026304
2	YT2	Hospital 2	578510	1029336
3	YT3	Hospital 3	577730	1034460
4	YT4	Hospital 4	568179	1025798
5	YT5	Hospital 5	550727	1042509
6	YT6	Hospital 6	549286	1057000
7	YT7	Hospital 7	549107	1021416
8	YT8	Hospital 8	546455	998440

Table 2: Summary of effluent water analysis

No.	Parameters	Units	Analytical methods
1	pH	-	TCVN 6492:2011
2	COD	mg/l	SMEWW 5220C:2017
3	BOD	mg/l	SMEWW 5210B:2017
4	TSS	mg/l	SMEWW 2540D:2017
5	Phosphate (PO_4^{3-})	mg/l	SMEWW 4500P-B&E:2017
6	Nitrate (NO_3^-)	mg/l	SMEWW 4500NO_3-E: 2017
7	Ammonium (NH_4^+)	mg/l	Hach Method 8038
8	Sulfide (S)	mg/l	SMEWW 4500-S^{2-}.F:2012
9	Coliform	MPN/100ml	TCVN 6187-2:1996

2.2. Data analysis

Microsoft Excel software was used for summarizing, performing simple statistics and plotting. The quality of the treated wastewater is assessed using the National Technical Regulation on medical wastewater when discharged into water sources used for domestic purposes (QCVN 28:2010/BTNMT, Column A) [6].

3.0 Results and Discussions

pH: The pH value in the study area (Figure 1) ranged from 7.11 to 8.56 with an average of 7.98. Minimum value is reached at YT5 position and highest value at YT8 position. The pH value at the sampling locations is higher than 7. Most of the monitoring sites have a neutral pH value, but pH at YT8 (8.56) exceeds the allowable threshold according to column A of QCVN 28:2010/BTNMT. pH could influence on efficiency of wastewater treatment plants since it directly influences on activities of microorganisms. In environment, the high pH value in surface water affects the normal development of aquatic species living in the water [7].

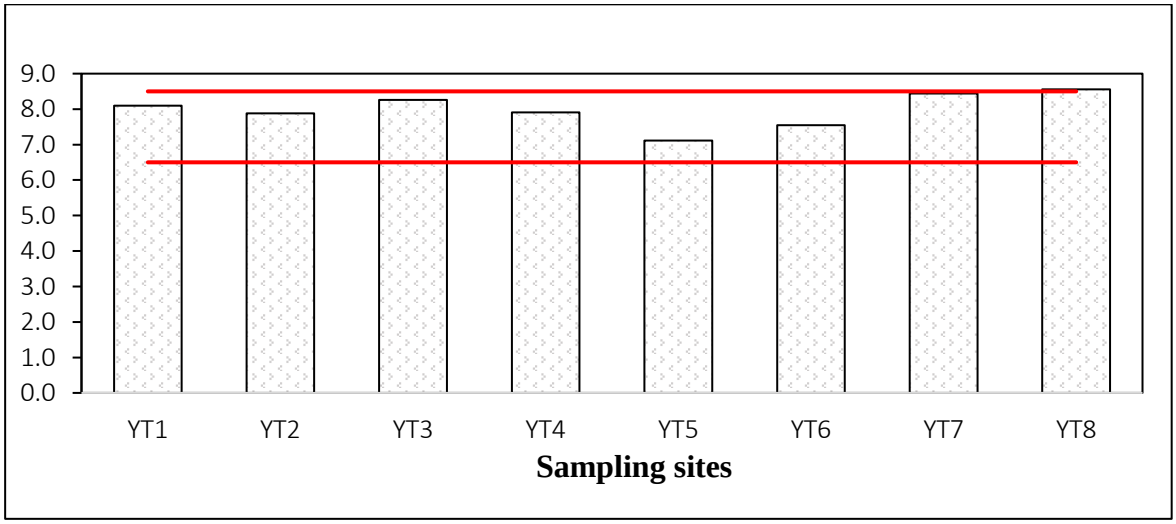

Figure 1. pH in medical wastewater effluent

Notes: The red lines represent the allowed pH values in column A of QCVN 28:2010/BTNMT

Total suspended solids: The results of Figure 2 showed that total suspended solids (TSS) were very low at YT3, YT5 and YT6 locations. The remaining sites had TSS values ranging from 6 to 209 mg/L. At monitoring locations, only YT1 had the highest TSS value (209 mg/L) and exceeded the allowable limit by 4.18 times higher than that of column A of QCVN 28:2010/BTNMT [6]. This result showed that the treatment performance of TSS at YT1 is needed to be soon improved. Total suspended substances are considered extremely hazardous in medical wastewater, so they need to be treated completely [8]. High TSS concentration in water would increase the cost of water treatment, affecting the life of aquatic species, especially the transport of pathogenic bacteria and pathogens spreading throughout a water body [9].

Figure 2. TSS in medical wastewater effluent

Chemical oxygen demand: COD values in the study area were recorded ranging from 13.3 to 82.6 mg/L. In which, YT1 has the highest COD value (82.6 mg/L) and YT2 has the lowest COD value (13.3 mg/L). At the same time, YT1 and YT4 are two locations with COD values exceeding the permissible limit of QCVN 28:2010/BTNMT, column A [6]. The COD concentration at the remaining positions are all below the allowable threshold. It shows that the effluents at YT1 and YT4 are not met the treatment efficiency. Therefore, modification of the treatment system for reduction of COD in the effluent is urgently needed since high COD could imply non-biodegradable organic matters in the wastewater effluents [10].

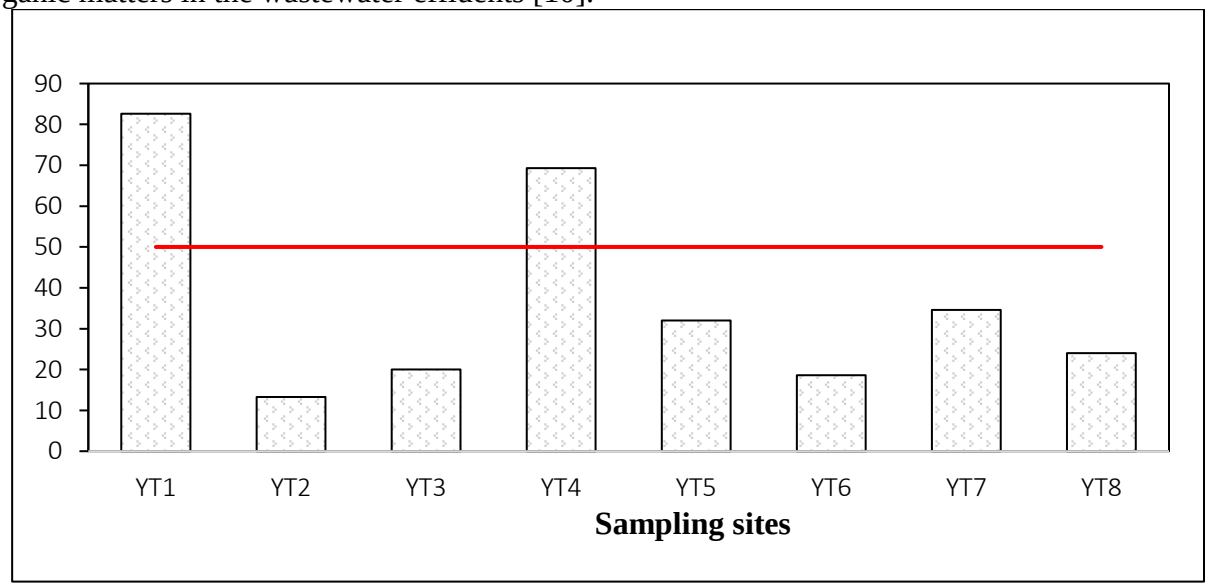

Figure 3. COD in medical wastewater effluent

Biological oxygen demand: The average value of BOD in the study area was 24.71 mg/L, ranging from 9.5 mg/L to 56 mg/L (Figure 4). YT1 is the position with the largest BOD value (56 mg/L) while YT2 (9.5 mg/L) has the smallest BOD value. Most of the locations had BOD values within the allowable threshold, except two locations YT1 and YT4. BOD and COD values in medical wastewater in the study area had similar tendency in the effluents. High BOD values lead to organic pollution [10]. Both COD and BOD are the indicators of organic pollution in medical wastewater [8]. High BOD in the effluent could lead to lower dissolved oxygen (DO) in the water which can affect biodiversity of a water body [2]. Some of the wastewater treatments need to adjust its operations to completely remove BOD in the effluent. Otherwise, the effluent will continue to pollute surface water in the study area.

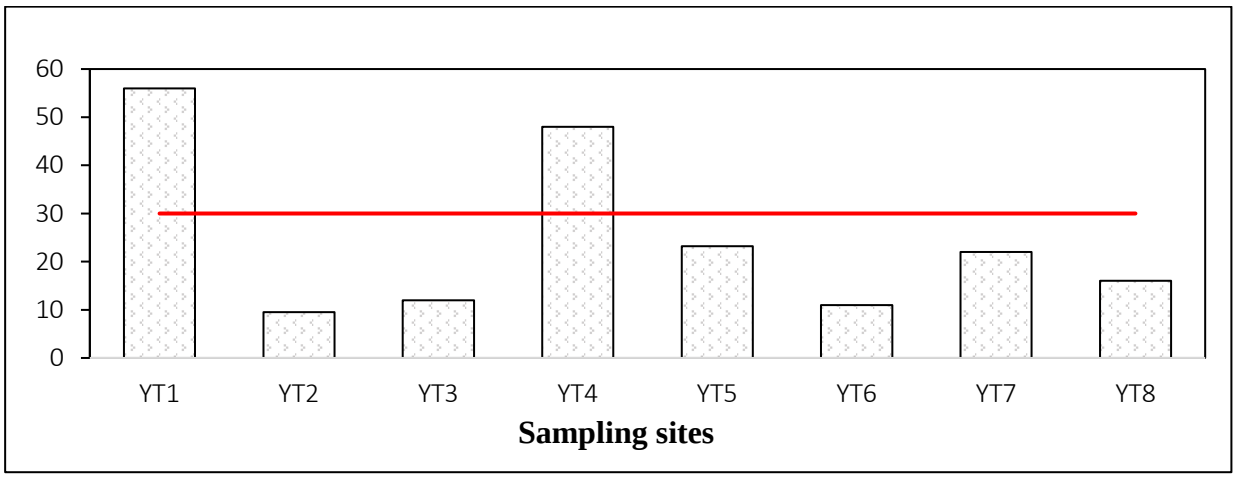

Figure 4. BOD in medical wastewater effluent

Phosphate (PO_4^{3-}): The concentration of PO_4^{3-} in the study area has an average value of 1.22 mg/L, ranging from 0.724 mg/L to 1.66 mg/L. PO_4^{3-} reached the lowest value at YT6 and the highest at YT5. There is not too much difference in PO_4^{3-} concentrations between medical wastewater systems. Compared with the allowable limit in column A of QCVN 28:2010/BTNMT [6], the concentration of PO_4^{3-} at medical treatment facilities are many times lower, meeting the PO_4^{3-} discharge requirement. However, these concentrations of PO_4^{3-} could result in locally increase of the amount of PO_4^{3-} in receiving water bodies [9]. The presence of high PO_4^{3-} could lead to potentially bloom of algae resulting in more water problems, for examples, increasing organic matters, depleting dissolved oxygen. As a result, water ecosystem become imbalance and biodiversity loss [2].

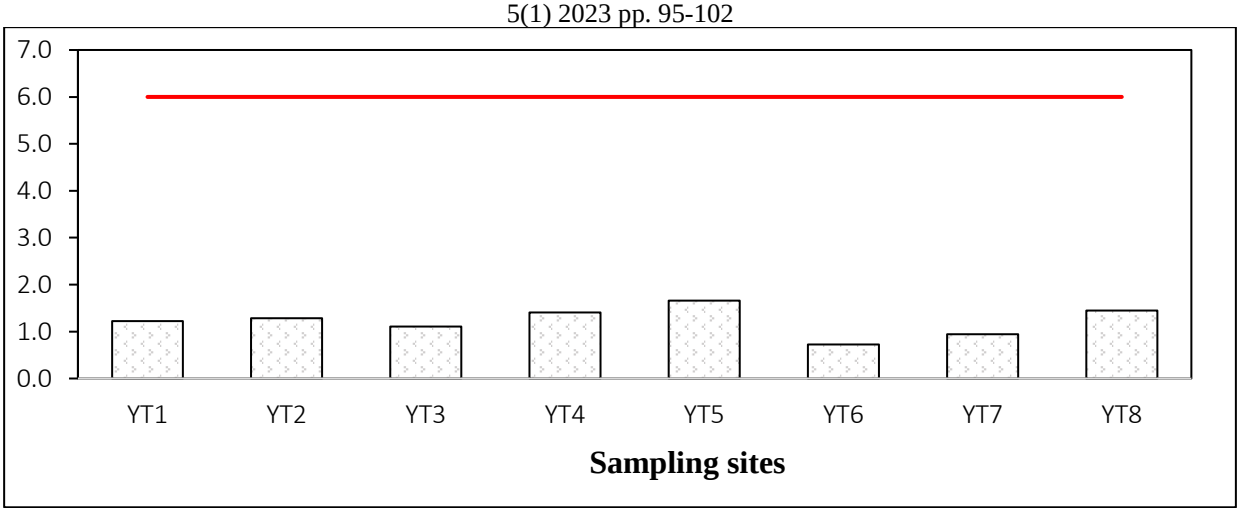

Figure 5. Concentration of PO_4^{3-} in medical wastewater effluent

Nitrate (NO_3^-): The NO_3^- indicator in the output wastewater of medical facilities in Bac Lieu province has a very significant difference. Specifically, NO_3^- values ranged from 3.85 to 44.51 mg/L, with an average value of 24.73 mg/L. The YT7 position has the lowest value of NO_3^- while the YT1 position has the largest value of NO_3^- (11.56 times higher than that at the YT7 position). NO_3^- concentrations at the locations YT4, YT6, YT7 and YT8 were within the allowable limit. The YT4, YT6, YT7 and YT8. The NO_3^- concentrations at the remaining positions of YT1, YT2, YT3 and YT5 exceeded the allowable threshold of column A of QCVN 28:2010/BTNMT [6]. According to Viet et al. [10], NO_3^- is the last and stable oxidized form of nitrogen in the aquatic environment and the NO_3^- concentrations increases during biological treatment and conversion from other nitrogen forms. High levels of NO_3^- concentrations in water can lead to eutrophication, which helps algae to thrive, affecting surface water quality and can be harmful to human health [2]. The results of the study propose that the effluent water should go into tertiary treatment to remove nutrients, particularly the nitrate concentrations.

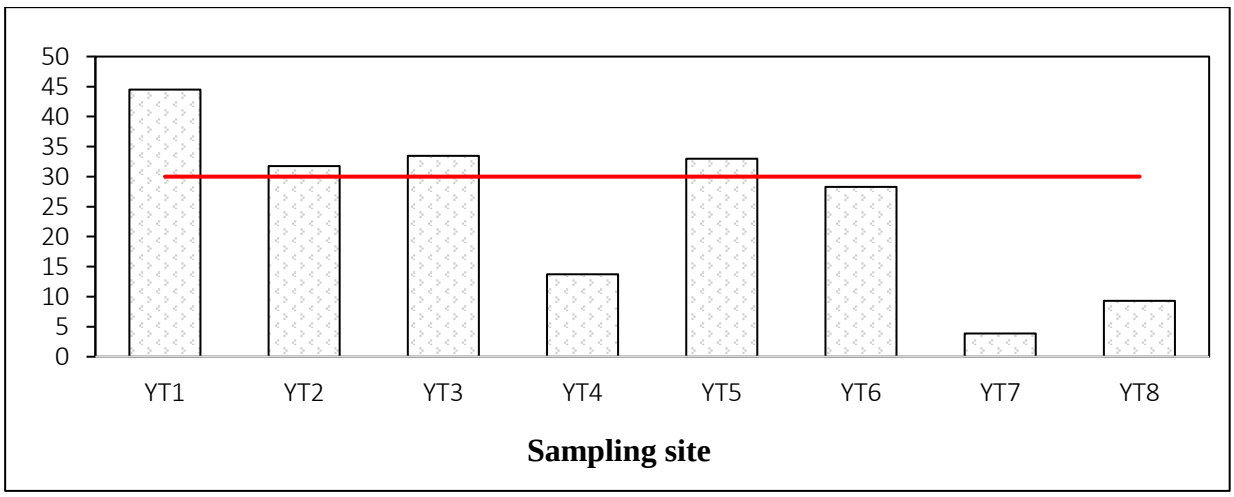

Figure 6. Concentrations of NO_3^- in medical wastewater effluent

Ammonium (NH_4^+): The NH_4^+ indicator results in Figure 7 show that the NH_4^+ value in the study area ranged from 0.01 to 2.63 mg/L (average 1.06 mg/L), reaching the highest value at YT5 and the lowest at YT7. All monitoring locations had NH_4^+ values lower than the allowable limit for column A of QCVN 28:2010/BTNMT [6], meeting the conditions for discharging waste into water sources used for domestic purposes. However, the ammonium concentrations in the effluent are still high comparing to the limits of surface water quality, which could potentially impact on aquatic life at

the receiving water bodies [9]. High ammonium concentration in surface water could trigger eutrophication which subsequently pollute the usable surface water [3,9].

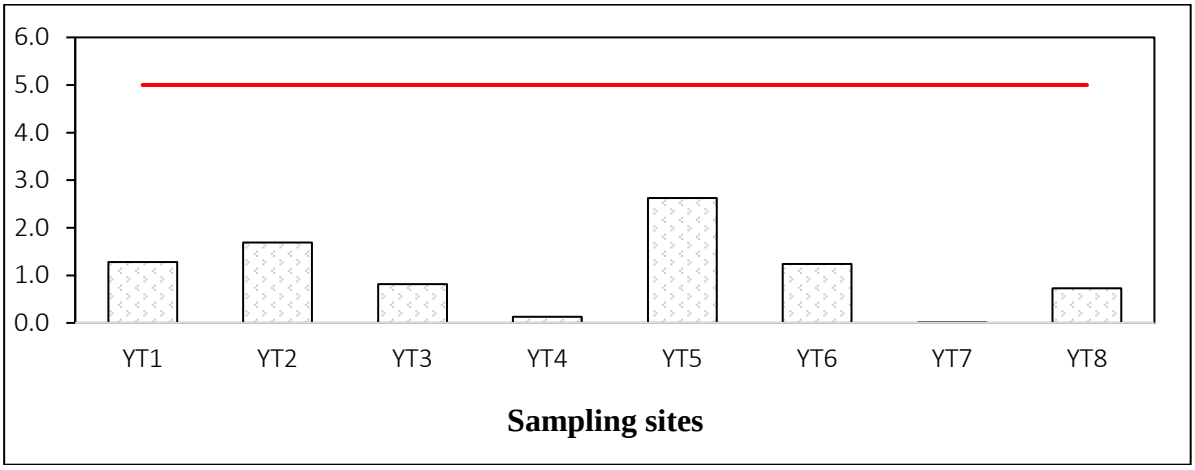

Figure 7. Concentration of NH_4^+ in medical wastewater effluent

Sulphide (S^{2-}): The results of monitoring the quality of medical wastewater showed that no sulphide value was detected in the study area. Therefore, all 8 monitoring locations in the study area had sulphide concentration within the allowable threshold of column A of QCVN 28:2010/BTNMT [6]. This result also shows that the treatment of sulphide in wastewater at medical wastewater treatment facilities is very effective.

Coliform: The densities of coliform in the medical wastewater after treatment at the observed monitoring sites (Figure 8) ranged from 2900 to 9300 MPN/100mL (average 5037.5 MPN/100mL). Position YT1 has the highest coliform value while YT8 has the lowest value. In addition to YT8 position, the remaining 7 monitoring sites all had coliform values exceeding the allowable threshold from 1.43 to 3.1 times higher than that is being stated at column A of QCVN 28:2010/BTNMT [6]. The high density of coliform leads to microbial contamination of water sources, which easily spreads harmful pathogens into water bodies, affecting health. According to Hung et al. [11], coliform and *E. coli* cause diseases related to the digestive system. The owners of the medical wastewater treatment facilities should improve their technology for completely treating the harmful bacteria before discharging into the surface water where it can be used for several domestic purposes [4].

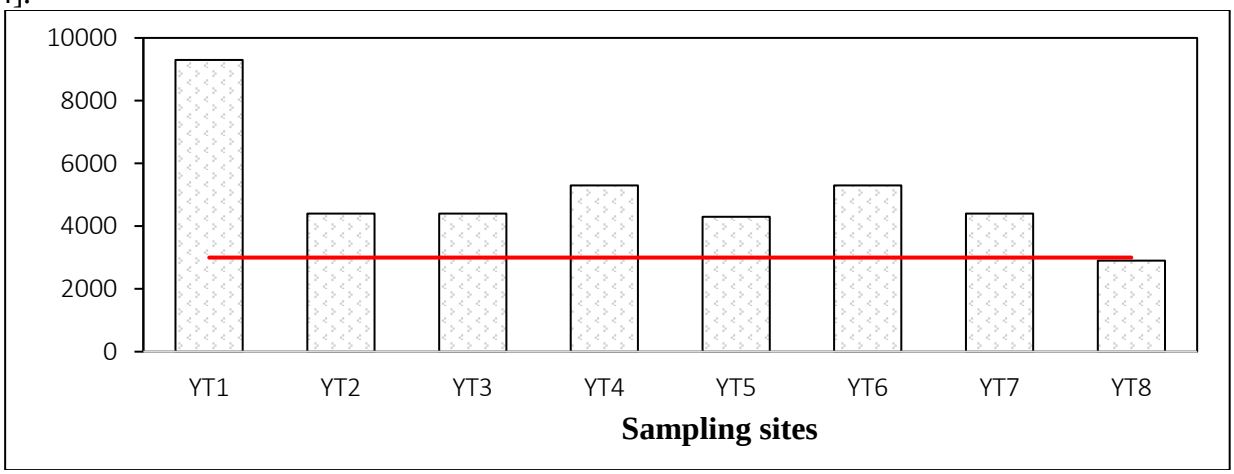

Figure 8. Coliform density in medical wastewater effluent

4. Conclusion

Research results show that the output wastewater quality of medical wastewater treatment systems is not effective. The indicators of pH, TSS, BOD, COD, NO_3^- and coliform in some treatment plants all exceeded the permissible limit according to the national technical regulations on medical wastewater quality (QCVN08:2010/BTNMT, Column A). This proves that wastewater from healthcare is a serious source of pollution to surface water quality in the study area. The relevant environmental management agencies should advise the medical treatment operators to choose an effective technology to treat medical wastewater to ensure that the permissible limit is reached.

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